928 MHz band by a wide-area system, will effectively be carried on radio links separate from those used for vehicle location.

MobileVision and, to a lesser extent, PacTel and Southwestern Bell nonetheless seek an enhanced use of voice channels in this band. For PacTel and Southwestern Bell, a satisfactory solution appears to lie within some provision for voice operations in narrowband forward link set-asides. As explained below, Pinpoint has no objection to a limited amount of spectrum, certainly much less than 1 MHz, being set aside for separate radiolocation-related emergency voice and for data operations in the 902-928 MHz band.

MobileVision, in its *ex parte*, apparently envisions a much more expansive use of voice in this band than any of its earlier pleadings suggest. Whether or not MobileVision did so in response to the *PacTel ex parte*, there simply is no reason to set aside spectrum for voice operations in the band on the scale suggested by this party.

As noted above, sufficient other spectrum allocations should support such communications. Indeed, MobileVision effectively recognizes this by observing the marriage of cellular and GPS. MobileVision attempts to argue that the possibility of such a combination would place AVM systems, without a strong voice component provided for in the 902-928 MHz final AVM rules, at a disadvantage. The fact of the matter is that nothing exists to inhibit a similar union of AVM (for vehicle location) with cellular (for voice communications). Cellular radio is a common carrier service available to the public without discrimination. Accordingly, what works with GPS in MobileVision's view is already equally available to AVM.

There would be no inefficiency in an arrangement combining an AVM operation with a cellular (or PCS or trunked radio) service vis-a-vis voice combined with a vehicle locating technology operating in the 902-928 MHz band, as MobileVision desires. As noted above, to accommodate voice in the 902-928 MHz band will require a distinct voice radio system in addition to the wideband pulse-ranging AVM system. The modest potential savings from combining a voice radio and a wideband pulse ranging unit within one radio cabinet for operation in different segments of the 902-928 MHz band do not begin to offset the enormous loss of AVM capacity that such a regulatory scheme would engender.

Accordingly, voice should be available for true emergency communications, if necessary, but to no greater degree. Recognizing that this might be a feature of AVM systems that would serve the public interest, Pinpoint proposes in its bandplan, detailed below, up to twenty 12.5 kHz channels (250 kHz total) set aside on a trunked basis equally available to all wide-area systems sharing the 902-928 MHz band and limited to such emergency communications.

V. WITH APPROPRIATE MODIFICATIONS, THE PACTEL BAND PLAN WOULD SERVE THE PUBLIC INTEREST.

Although the *PacTel ex parte* acknowledges the feasibility of band sharing, the above discussion demonstrates that PacTel's recently proposed band plan and service rules would not serve the public interest. Pinpoint understands that PacTel envisions uncoordinated (at least on a time basis) operation of mobiles in the shared wide-band

portion of its plan (i.e. the 6.5 MHz from 904 - 910.5 MHz). Apparently, the mobiles would operate with 10 watts or less of power and possibly employ CDMA in order to facilitate simultaneous transmissions by different systems in the same general geographic area. Absent a time-sharing modification, such a scheme would be incompatible with operation of the Pinpoint system in the same area. The Pinpoint wideband base stations, operating at power levels exceeding 10 watts, would likely interfere with the receipt of the PacTel mobile transmissions. Moreover, dedicating only 6.5 MHz of bandwidth for shared operation would severely limit the position fixing capacity of such systems.

The PacTel plan, however, with modifications, could set the stage for a much more competitive and capable AVM marketplace. Time sharing of most of the 902 - 912 MHz sub-band would permit higher speed vehicle location using Pinpoint-like systems. During other time slots, the PacTel system could operate largely in the manner envisioned in its *ex parte* (*i.e.* a 1.5 MHz wideband forward link coupled with a 6.5 MHz wide band within which the mobile might send a pulse for location purposes).

From the standpoint of service to the public, an even better solution would be to permit those wide-area systems that can share on a co-primary basis with local area systems to operate in the 912-928 MHz portions of the band. This would provide the needed bandwidth to permit the use of very high speed vehicle location needed to facilitate intelligent vehicle-highway system services. In such a scenario, those wide-area systems that elected to operate in the 912-928 MHz band would effectively trade

greater bandwidth (and hence speed) against the added noise likely to be present. Such an approach would foster not only a variety of wide-area solutions to AVM but would accommodate local-area needs with less fear of encountering wide-area systems that were relatively intolerant to interference.

The earlier Pinpoint band plan proposal[49] represents an effort at a compromise designed to accommodate existing wide-area AVM system proposals. Many of the advantages -- from a technical and competitive standpoint -- of the earlier proposal can be achieved through the following modifications to the PacTel *ex parte* proposal:

- While the set aside of 902-912 MHz for wide-area systems could be preserved, only the 902.0-902.5 MHz sub-band should be available for voice operations and forward links outside of a shared wide-band. In this way, the bulk of the band could be preserved for AVM and LMS, for which the band is uniquely suited.
  - Specifically, the 250 kHz from 902.00-902.25 MHz sub-band could be set aside for emergency and incidental voice channels (12.5 or 25 kHz) for wide-area system operators. Preferably, these channels would be made available on a trunked-radio basis to all such operators. Of course, operators would remain free to combine their AVM operations in the 902-912 MHz band with voice capability obtained from cellular systems, PCS, or other land mobile radio facilities.
  - The 250 kHz from 902.25-902.50 MHz sub-band should be set aside for narrowband forward links or timing/system control channels for wide-area system operators. These generally would not be shared but would be dedicated each to particular systems, although time sharing of such channels would not be precluded.[50]

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[49] *See* Pinpoint Comments at 31-39.

[50] The Commission should give present users of forward links at the frequencies currently specified in the rules -- meaning PacTel in the six cities in which it has operations -- a reasonable period to (continued...)

- The 902.5-912.0 MHz sub-band (9.5 MHz) would be assigned for wide-area systems only, to be shared among *all* qualified applicants -- not just two, as PacTel proposes -- that file in each market's filing window.

  - Wide-area system applicants need only apply for the amount of spectrum that they intend to use. In other words, they need not design a system to use all of the available spectrum. This would preserve wide-area system design flexibility as much as possible by not putting arbitrary constraints on bandwidth, which would unnecessarily restrict both the vehicle location rate and data messaging throughput. Further, if they use less than the full shared band, then they would locate their occupancy as close to the available band edges as possible, to allow for possible future entrants.

  - Sharing arrangements would be determined by the qualified applicants in each market through negotiation. Conceivably, such an arrangement, while it would be based on time sharing, could incorporate frequency division or CDMA as well. For example, System A could use the entire 9.5 MHz sub-band for each even half-second. Systems B and C could use the sub-band on the odd half-seconds, dividing the spectrum into 4 MHz and 5.5 MHz channels for their respective use. During its time slices, an operator might increase its capacity by having multiple mobiles on the air simultaneously. Operators could also agree to let their mobiles operate on a CDMA basis during each other's time slices, as PacTel has implied it may do in its *ex parte*.[51]

  - There would be no dedicated wideband forward links, as PacTel proposes, because that would compromise the ability of the spectrum to be shared by more than two qualified operators. Those licensees that perceive a need for spectrally distinct wideband forward links or data channels could divide the

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[50](...continued)
migrate these links to the 902.25-902.50 MHz sub-band. The narrowband forward links would be shared only in necessary to accommodate a large sharing group. In such a case two licensees might share one forward link or a licensee could arrange for an exclusive forward link in a nearby paging or narrowband PCS band.

[51] For an illustration of a larger-scale hypothetical sharing arrangement, see Exhibit A attached hereto.

bandwidth they have access to as they see fit *when* they have access to the spectrum.

- Although local-area systems would not be able to center their illuminating signals in this sub-band, they could attenuate their wideband signal's sidebands below 912 MHz subject to strict power limits, such as those proposed by Pinpoint in its comments in this proceeding. Adapting these concepts to the instant proposal, the effective radiated power falling into the band from local-area systems would be limited to 200 mW at 911-912 MHz and 50 mW below 911 MHz.

- Pinpoint believes that existing local-area systems should be permitted to remain in this band for a specified period and then only have to move when they are causing actual harmful interference to a licensed wide-area system as part of a mutual agreement between the licensees pursuant to the Commission's sharing guidelines.

- The 912-928 MHz sub-band (16 MHz) would be available for local-area and wide-area systems. All AVM systems would operate in this band on an equal priority basis with local-area systems pursuant to the sharing guidelines set forth in Section 90.173 of the Commission's Rules, with the exception of wide-area system narrowband forward link and incidental voice operations, which would occur in the 902.0-902.5 MHz sub-band. It is not contemplated that sharing between local- and wide-area systems would be on a time shared basis.

  - If more than one wide-area system wished to utilize this band, then all such wide-area systems would have to share among themselves on a time shared basis, much as would occur in the 902.5-912 MHz sub-band.

  - In order to utilize this sub-band, a wide-area system operator would be required to apply within the same filing window as all other wide-area applicants. All qualified applicants would participate in the negotiated sharing, and a single operator may negotiate for the right to utilize part or all of both the 902.5-912.0 and 912-928 MHz sub-bands or just one of the sub-bands.

These modifications to the PacTel plan improve it significantly by setting the stage for a more competitive and spectrally efficient provision of AVM and LMS. The

constraints on system design would be minimized, subject only to the arranged sharing plan.

Applicants should be required to demonstrate (i) a firm financial commitment of sufficient resources to build and operate for one year, without revenues, a minimum acceptable system covering an area serving at least 50% of the residential population of the market with position-fixing capability; (ii) use of a demonstrably proven technology -- through commercial or experimental operation -- that meets minimum throughput and robustness criteria;[52] and (iii) legal qualification to be a licensee. No applicant should be permitted to have an ownership interest in any other applicant above some *de minimis* publicly-traded amount of stock. The FCC would proceed to name as tentative licensees all of those who had applications acceptable for filing. The tentative selectees would then be known as the "sharing group."

The sharing group would then be given six months within which to agree upon a sharing plan and submit it to the FCC for approval. At the outset of any such negotiation, each member of the sharing group would be given the right of equal access to the shared spectrum once its system becomes operational. If a sharing arrangement is not agreed upon within the period specified by the Commission, the licensees would share the spectrum pursuant to a simplified sharing scheme set up as a default in the Commission's Rules, based on a common timing standard (*e.g.* the GPS timing signal)

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[52] *See* Pinpoint Comments, Exhibit D.

and time slices of into equal increments that would give qualified applicants access to the entire wide-area spectrum on a round-robin basis.[53]

Permitting all qualified applicants to share on a co-primary basis avoids the serious procedural and conceptual difficulties implicated in PacTel's *ex parte* proposal, whereby primary status in a market is accorded to the first two systems with "1500 paying units."[54] What would constitute a "paying unit?" What if the second and third systems to have 1500 paying units were to achieve that goal on the same day? How would sharing be accomplished before any systems have 1500 paying units? If multiple systems can share with fewer than 1500 paying units each, what keeps them from sharing if more than two have over 1500 units? In short, the problems with determining when the "race to duopoly" had been won would alone outweigh any difficulties with negotiated sharing under Pinpoint's plan and be more likely to inject the Commission into fractious litigation over factual issues.

Finally, because the shared band would be available to only one operator at a time, or to operators that *agree* to use the band simultaneously, Pinpoint sees little merit in the low power limits proposed by PacTel. These power levels, nonetheless, may serve as a practical consideration for wide-area systems agreeing to share spectrum on a CDMA basis among themselves during a single time increment. While the limits proposed by PacTel in its *ex parte* may be appropriate for the narrowband voice and

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[53] *See* Pinpoint Comments at 35-38 for a more detailed account of Pinpoints proposed sharing negotiation procedures.

[54] *PacTel ex parte* at 3.

forward links, there is no reason to adopt the limits PacTel proposes in the 902.5-928 MHz band. Higher power limits are required to permit wide-area system operators to maintain reliable operations as the noise floor in the band increases from operations having lower priority to the band. Accordingly, Pinpoint continues to urge the FCC to adopt the power and power spectral density limits set forth in its Comments and Reply Comments: 625 watts per MHz (minimum 2 MHz) with a 5 kW maximum.[55]

VI. AVM/LMS SYSTEM LICENSES SHOULD BE GRANTED ON THE BASIS OF METROPOLITAN STATISTICAL AREAS AND RURAL SERVICE AREAS

Pinpoint urges the Commission to foster the development wide-area AVM systems by licensing such systems on the basis of Metropolitan Statistical Areas ("MSAs") and Rural Service Areas ("RSAs") rather than by the Rand-McNally Basic Trading Areas ("BTAs") as recommended by PacTel's *ex parte*, or the 55-mile co-channel separation originally proposed in the *NPRM*.[56] Even under the "non-exclusive" licensing system envisioned by Pinpoint, use of geographic areas in the licensing process will facilitate system deployment and make it easier for wide-area licensees to work out sharing arrangements.

MSAs and RSAs are preferable to BTAs for wide-area systems because the MSA/RSA divisions are perfectly congruent with those employed in cellular licensing.

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[55] Pinpoint Reply Comments, Technical Appendix at 14.

[56] *See* Pinpoint Comments at 35, n.49.

As AVM systems develop, wide-area AVM will find its greatest application in support of vehicular applications. Many of these will be complementary to cellular.

Use of the MSAs/RSAs instead of the BTAs will also facilitate the deployment of the technology in selected smaller markets that may not otherwise be economically justifiable under the BTA concept. There are 734 MSAs and RSAs, but only 487 BTAs. While Pinpoint concurs in the reasonableness of a requirement to cover 50 percent of the population of the geographic division, as suggested by PacTel, the size and population distribution of certain of the BTAs would reduce the economic feasibility of extending service to large but less densely populated BTAs.

Finally, use of the BTAs would likely require the negotiation and payment of a royalty fee to Rand-McNally, which has asserted rights to the BTA concept. While the Personal Communications Industry Association has negotiated a blanket license for the use of the BTA concept with respect to the PCS, SMR (including Expanded SMR) Service, and the Local Multipoint Distribution Service, the license agreement does not apply to AVM nor to the proposed LMS. For these reasons, Pinpoint urges the Commission to employ the MSA/RSA boundaries for the purpose of licensing under rules developed in this proceeding.

VII. CONCLUSION

For the foregoing reasons, the Commission should adopt time sharing by qualified wide-area system applicants. Dedicated forward link and emergency analog voice operations should be moved to the lower edge of the band to ensure the

maximum amount of bandwidth available for vehicle location. Thus, the entire 902.5-928 MHz band should be available for sharing by wide-area systems. The 912-928 MHz band would also be shared with local-area systems pursuant to the Commission's private land mobile radio sharing guidelines.

Respectfully submitted,

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Exhibit A

Hypothetical Example of Time-Sharing by Wide-Area AVM Systems in the 902-928 MHz Band

Under Pinpoint's modification of PacTel's new band plan proposal, all financially and technically qualified wide-area AVM system applicants would share the 902.5-912 MHz sub-band among themselves and the 912-928 MHz sub-band among themselves and with local-area AVM systems. See Figure 1. The actual number of wide-area AVM systems in a market would be determined by market forces. Qualified applicants would be given an opportunity to negotiate appropriate sharing agreements. If there were more qualified applicants than could be economically viable, Pinpoint would expect some consolidation and withdrawal to occur. In any event, however, the solution would be market-driven.

This Appendix illustrates one possible sharing arrangement under such a scheme assuming ten hypothetical wide-area AVM applicants in a market.

Table 1 lists the basic characteristics of each applicant's proposed system in terms of occupied bandwidth, use of CDMA, ability to share with local-area systems, and the need for a narrowband forward link. Figures 2A through 2D illustrate how the 902-928 MHz could be shared by the applicants on a time-sliced basis. Briefly, the time could be divided into four equal time increments every cycle, which could be 1 second, 2 seconds, 4 seconds, or some other period in length. During each time increment, one or more of the applicants would have access to the available spectrum, through a combination of frequency division

and/or CDMA. All applicants would have access to the emergency voice channels on a trunked-radio basis.

The solution suggested here is just one of many that could be agreed to by the applicants in this hypothetical scenario. More time increments, for example, could have been used, and the combinations of the Systems with access to the spectrum in some or all of the time increment could have been different. Systems H and I might have split the 912-928 MHz band during the same time interval, to name one variation. System E could have used the entire 912-928 MHz sub-band, to name another. And Systems A and B might have had access to the 902.5-912 MHz sub-band in a separate time increment from System C, to name a third.

The basic point is that the Pinpoint revision to PacTel's new band plan proposal allows for the implementation of a wide-variety of AVM systems pursuant to a practical time-sharing approach.

TABLE 1

Qualified Applicants
in Hypothetical Sharing Arrangement

System A:	4.75 MHz, using CDMA, cannot share with local-area systems, needs narrowband forward link
System B:	4.75 MHz, using CDMA, cannot share with local-area systems, needs narrowband forward link
System C:	9.5 MHz, using CDMA, cannot share with local-area systems, needs narrowband forward link
System D:	9.5 MHz, cannot share with local-area systems, needs narrowband forward link
System E:	16 MHz, can share with local-area systems, needs narrowband forward link
System F:	4 MHz, cannot share with local-area systems, needs narrowband forward link
System G:	4 MHz, cannot share with local-area systems, needs narrowband forward link, uses separate 1.5 MHz wideband forward link during its time interval
System H:	8 MHz, can share with local-area systems, needs narrowband forward link
System I:	8 MHz, can share with local-area systems, needs narrowband forward link
System J:	16 MHz, can share with local-area systems, needs no separate forward link

Pinpoint Revision To PacTel Band Plan Proposal

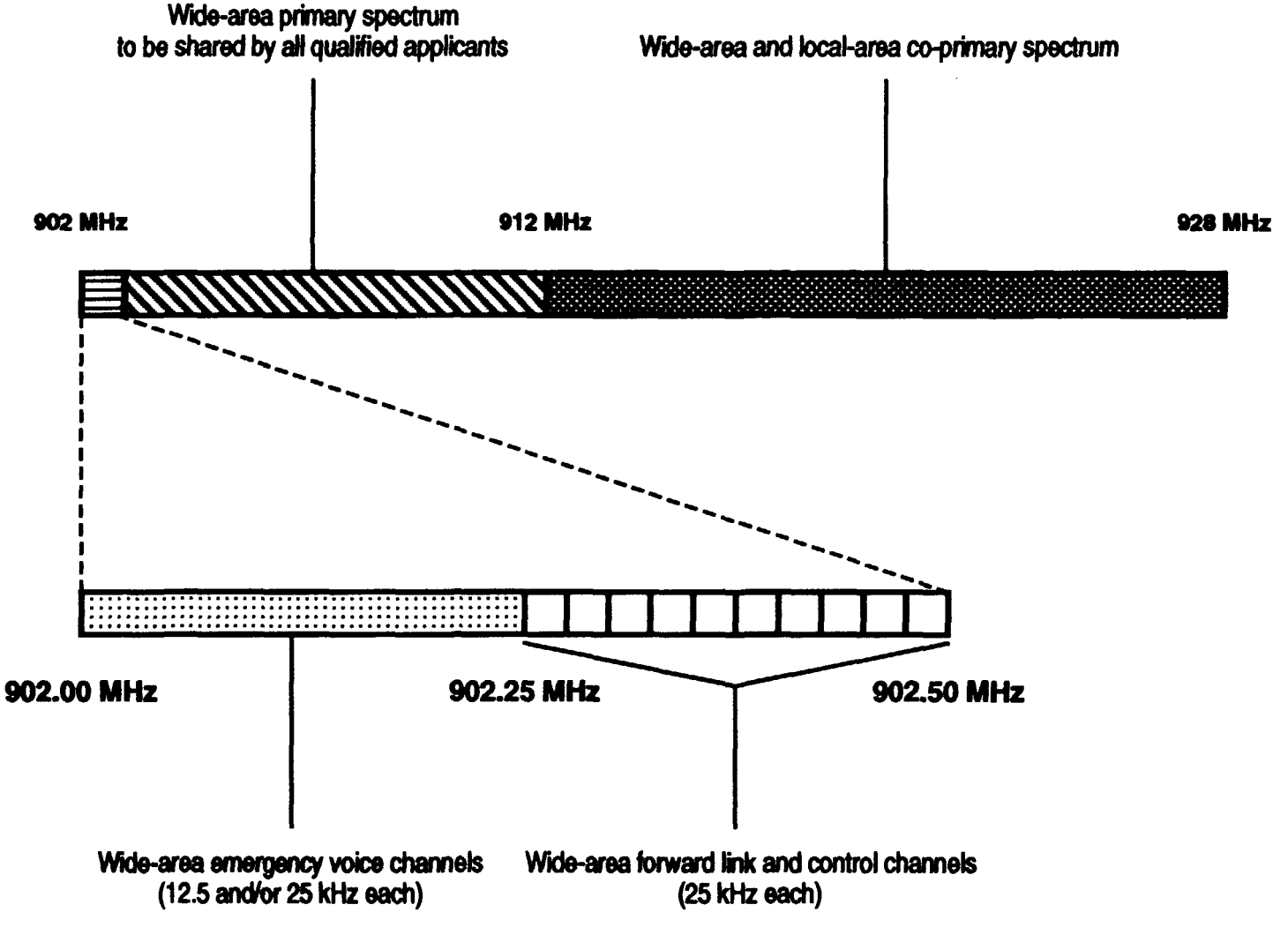

Figure 1

Hypothetical Sharing Arrangement: First Time Increment

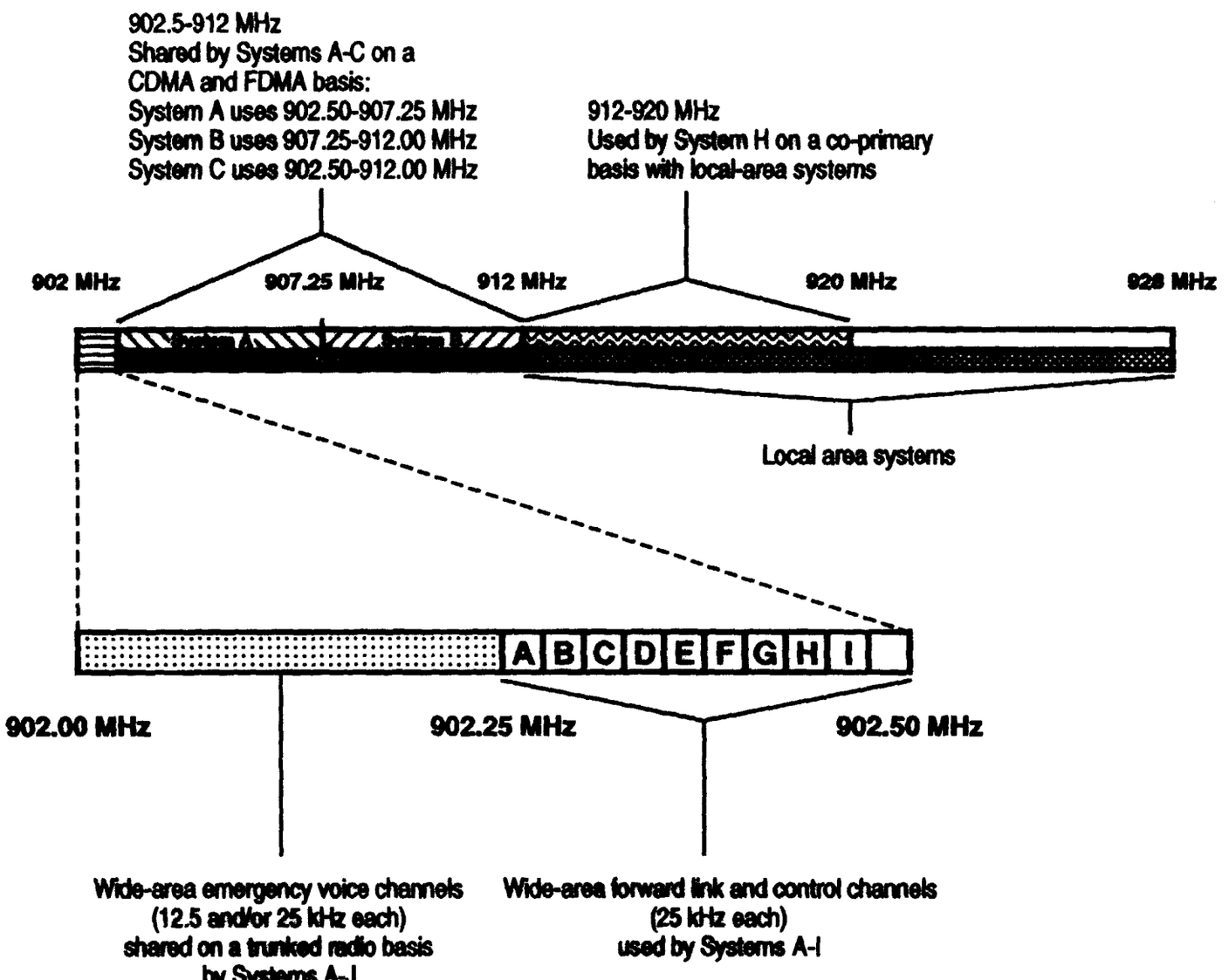

Figure 2A

Hypothetical Sharing Arrangement: Second Time Increment

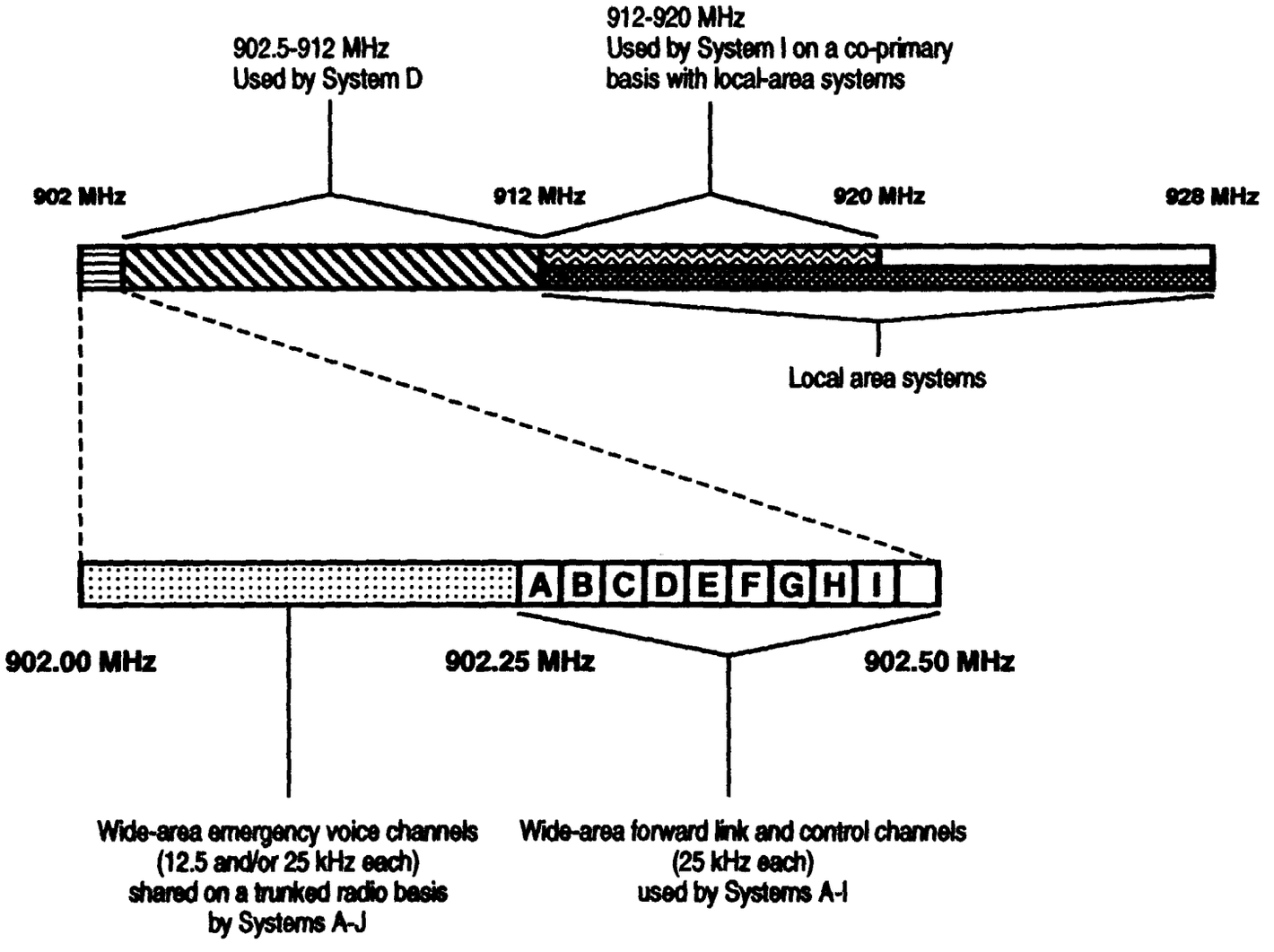

Figure 2B

Hypothetical Sharing Arrangement: Third Time Increment

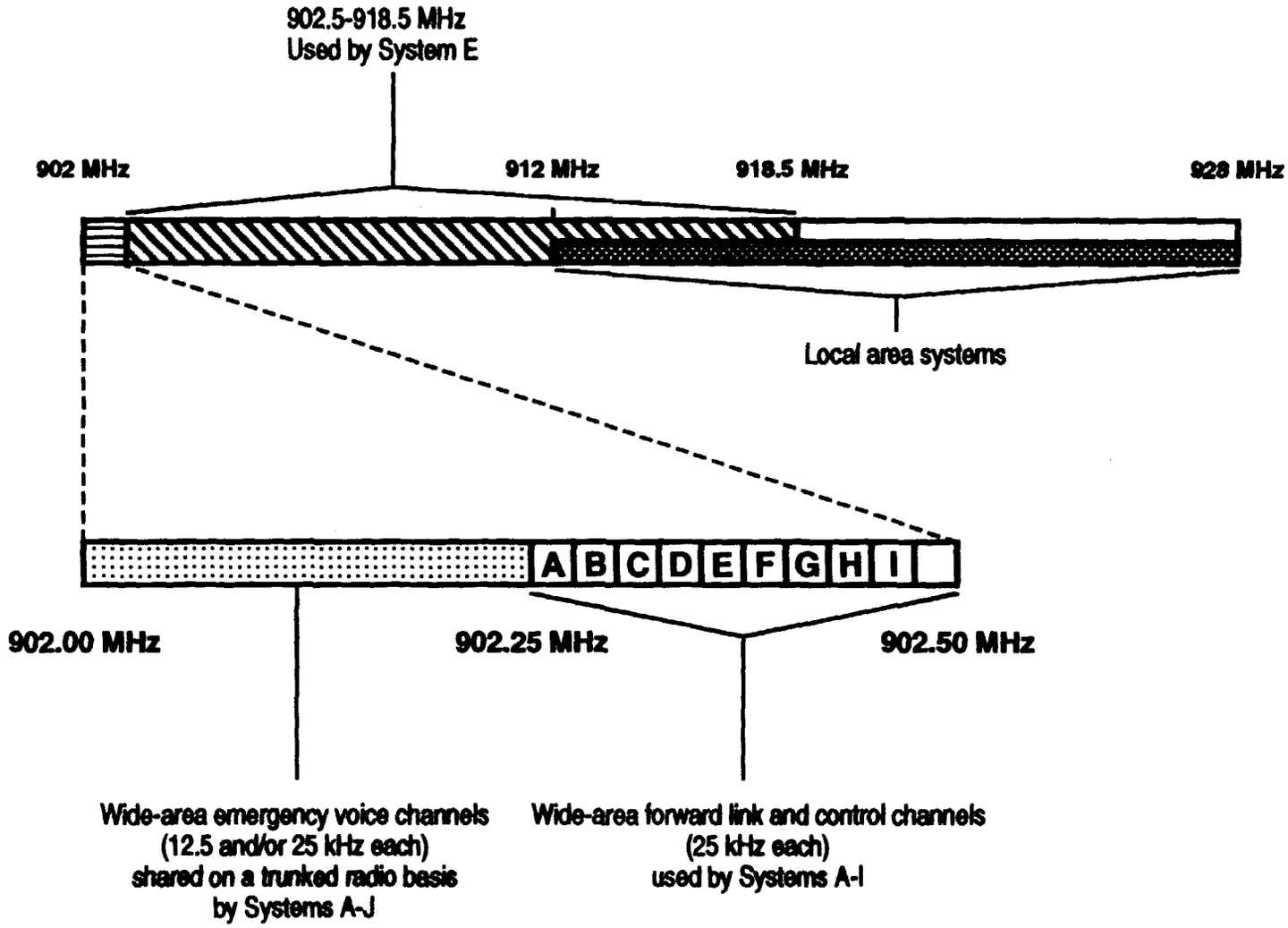

Figure 2C

Hypothetical Sharing Arrangement: Fourth Time Increment

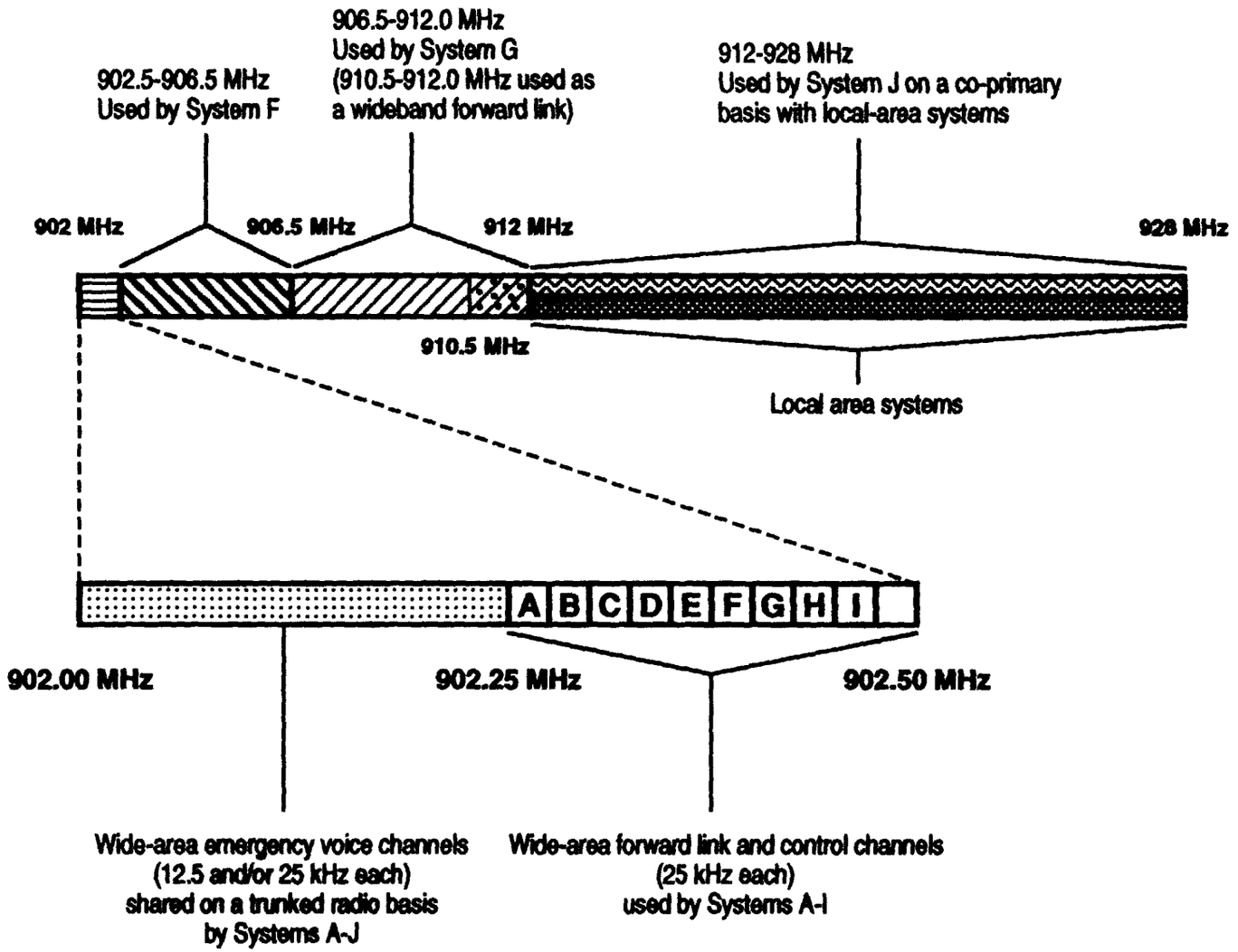

Figure 2D

EXHIBIT B

TECHNICAL EXHIBIT

Discussion of Factors Affecting Throughput in Wide-Area AVM Systems

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This technical appendix discusses the practical considerations affecting the throughput of a wide-area AVM system. As explained below, depending on design choices, throughput can increase at a rate faster than changes in occupied bandwidth as a practical matter, even though, as a theoretical matter, the rate of data throughput increase is proportional to occupied bandwidth. Discussions of the data throughput of AVM systems that rely merely on theoretical considerations, such as that contained in a report recently prepared for Southwestern Bell Mobile Systems in PR Docket No. 93-61,[1] are incomplete and potentially misleading.

The principles of Shannon, Cramer-Rao and others set outside theoretical limits for system throughput. However, providing high-speed AVM and data communications in the severe multipath distorting environment of 900 MHz mobile radio is a very arduous affair with important practical consequences for system design and operation. A system's performance is reduced well below the values predicted for one or more of

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[1] "Capacity and Interference Resistance of Spread-Spectrum Automatic Vehicle Monitoring Systems in the 902-928 MHz ISM Band" prepared by the Mobile and Portable Radio Research Group, Virginia Tech (January 14, 1994) for Southwestern Bell Mobile Systems and filed with the Federal Communications Commission on February 2, 1994.

the following reasons: multipath distortion, high levels of in-band interference, the different "near-far" effects of that interference on the mobile and the base station, the requirements to maximize the efficient utilization of very scarce spectrum, and the minimization of equipment and infrastructure costs. These theoretical limits, in short, describe operation under only "idealized" conditions that are rarely, if ever, realized.

In Pinpoint's ARRAY™ system, a supra-linear relationship between data-throughput and bandwidth arises because of the practicalities available to the system designer of such systems, rather than an idealistic considerations based on Shannon's Theorem of channel capacity. The radio location link's requirements, such as ranging resolution, time per fix, and power (determining received s/n ratio at desired range, given the jamming conditions), are the primary determinants of the needed occupied bandwidth. The bandwidth resulting from such consideration is usually much greater than the bandwidth necessary to carry the data required for the radio location system's control and messaging function, as predicted by Shannon's Theorem for a white-noise limited channel. The ARRAY™ system, however, handles the data/control channel quite differently, resulting in a significant reduction of the amount of bandwidth and airtime needed to accomplish the system's functionality.

In short, the ARRAY™ system optimizes most of the factors affecting throughput performance described above, allowing scarce spectrum to be shared effectively. This

is accomplished by using a signaling (modulation/de-modulation) technology that is suitable for both high-speed radiolocation and high-speed data communication in a communications environment exhibiting severe multipath distortion (as is typical of 900 MHz mobile radio). Indeed, vehicle location and data messaging functions are performed *simultaneously* on the single, wide-band messaging/control signal *without* the need for separate, exclusive forward links as in other AVM system designs. In other words, each message symbol is also a complete ranging pulse.

By measuring the time-of-arrival of each symbol in the control data message, the functionality of spectrum use is doubled. Because the system accomplishes messaging while it performs ranging, no additional spectrum is required. This raises the overall throughput of the ARRAY™ system relative to one that performs ranging and sends data sequentially in the same bandwidth.

The ARRAY™ system, therefore, requires little extra overhead for network control. Almost the whole network control message transmitted *is* the signal used for the ranging time-of-arrival estimate. Consequently, the system operates at throughput rates respectably near the Cramer-Rao bound for radiolocation throughput. Under these circumstances changes to the throughput of the network occur much more rapidly than changes in the occupied bandwidth. Typically, these changes to radiolocation throughput are with the cube of the bandwidth when narrowband jammers are the

dominant interference, or as the square of the bandwidth if broadband noise is the dominant interference.

However, from the perspective of data message delivery over the ARRAY™ network, throughput is limited mainly by multipath distortion constraints, encoding and decoding complexity, and the cost needed to transmit data at high speed -- *not* by Shannon's prediction of throughput per Hz. In other words, under conditions existing at 900 MHz, a network's messaging capacity is very much less than the "theoretically predicted" throughput based on signal-to-noise ratio and occupied bandwidth alone. In all wide-area 900 MHz AVM systems described in Docket 93-61, spread-spectrum techniques are being used to counteract the various effects of multipath distortion. The code sequences used in these techniques tend to have binary jumps in length or duration, and the number of sequences to choose from increases rapidly with sequence length. As a result, the relationship between data throughput rate and occupied bandwidth is a complex affair, depending on which design requirement is being traded against another (such as process gain vs. intersymbol interference vs. sequence correlation-sidelobe distortion, etc.). As a general practical matter, the adverse effects of very limited numbers of system design choices diminish as occupied bandwidth increases. As a result, data throughput appears, as a practical matter, to grow faster than the increase in bandwidth. In reality, the practical throughput does not exceed the limits predicted by Shannon *et al.*, but approaches it as bandwidth increases.